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Aeration as a Partial Treatment for Dairy Wastes*

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Previous reports have been made on laboratory studies on aerobic oxidation of a simulated dairy waste (0.1 per cent skim milk solids) in a continuous flow system[2]. The maximum rate of loading for steady-state operation was 10 per cent of the volume an hour. A complete solids balance showed that 50 per cent of the milk solids was assimilated into cell tissue or sludge; the remaining 50 per cent was oxidized to CO_2 and water to gain energy for this assimilation. These results were confirmed and extended by manometric measurements of the rate and extent of oxidation of milk solids by activated sludge[1].

This rapid aeration process with a centrifugal separation of the bacterial cells was proposed as a possible system for treating dairy wastes in industry.

The pattern of operation in dairies is such that a large proportion of the waste is produced in a few hours in the morning, with almost none between 5 p.m. and early morning. Therefore, experiments with a fill-and-draw system which could take advantage of this intermittent production of waste have been made. The reductions in B.O.D. were such that discharge of the total effluent might be considered when complete treatment of the effluent is not required. Furthermore, the effluent would be relatively stable and could be treated satisfactorily in a municipal sewage system.

EXPERIMENTAL

The laboratory equipment employed was a Humfeld aerator maintained at 30° C. (86° F.) as previously described[2]. A drain was inserted so that all but 2.4 L., 20 per cent of the total capacity, would be removed. The simulated waste was added in four hours; 9.6 L. were added daily. C.O.D. analyses[3] were made approximately hourly;

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the samples drawn during the night were frozen until analyzed the next day. In the morning, 9.6 L. of the aerated material were drained and fresh waste was added. The rate of aeration was approximately 1 volume of air per volume of liquid a minute and was continued throughout the 24-hour period. The samples were centrifuged to throw down the cells, and the C.O.D. of the supernatant was then determined. The mechanical action of the stirring blades in this fermentor produces a light, finely divided dispersion of the cells, which does not settle in the manner characteristic of activiated sludge.

RESULTS

Figure 1 shows results of three successive daily experiments in which a solution of 0.1 per cent skim milk solids was the simulated waste. The C.O.D. of the influent was 1050 ppm; the 5-day B.O.D. was 640 ppm. The total C.O.D. in the tank increased rapidly until it approached that of the effluent but started dropping within the four hours during which the waste was added. In several cases, the zero-hour samples were not taken until after addition of influent was started. A simultaneous rise and fall of the soluble C.O.D. showed that the waste was not being assimilated as rapidly as added. In about eight hours after the experiments were initiated, the rapid oxidation was complete. A much slower oxidation of the bacterial cells themselves continued, with a slight drop in the total and soluble C.O.D. of the solution[1]. Results of three experiments agree rather well; differences in rate of addition of the waste and sampling errors apparently account for the variations observed.

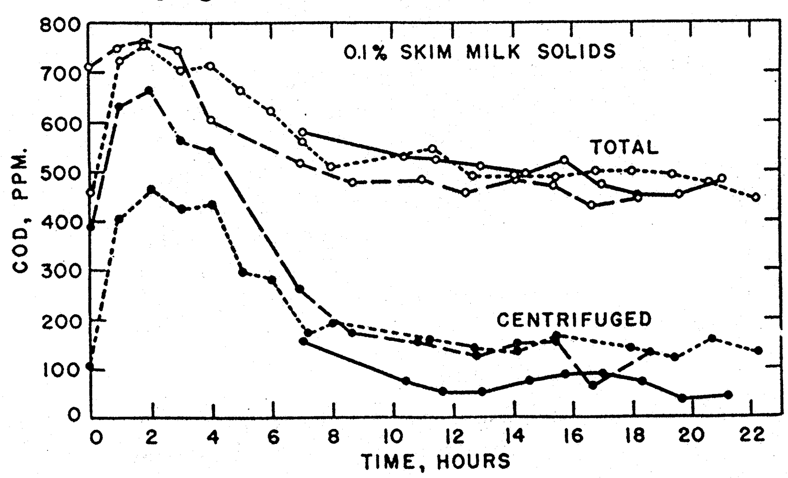

FIGURE 1.

Figure 2 shows the results obtained in a second set of experiments in which 0.5 per cent whey solids in solution was added. The course

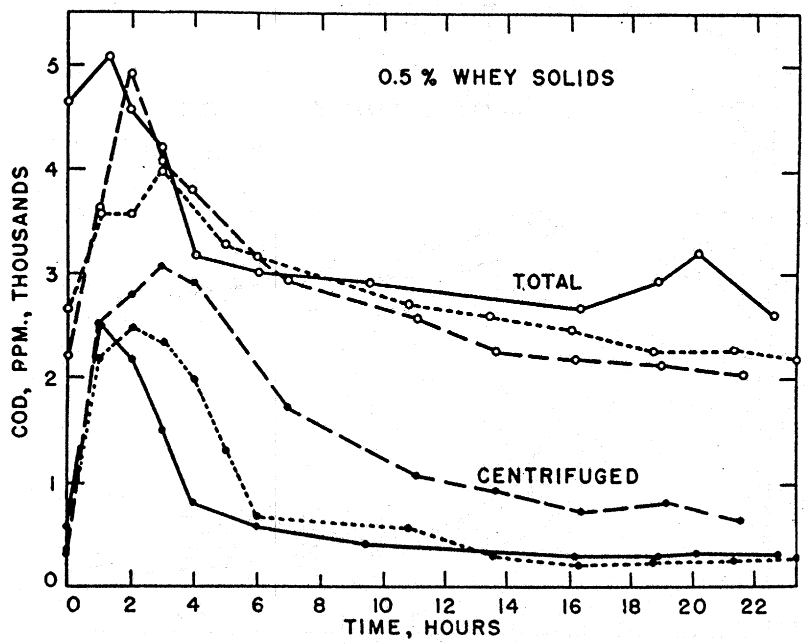

FIGURE 2.

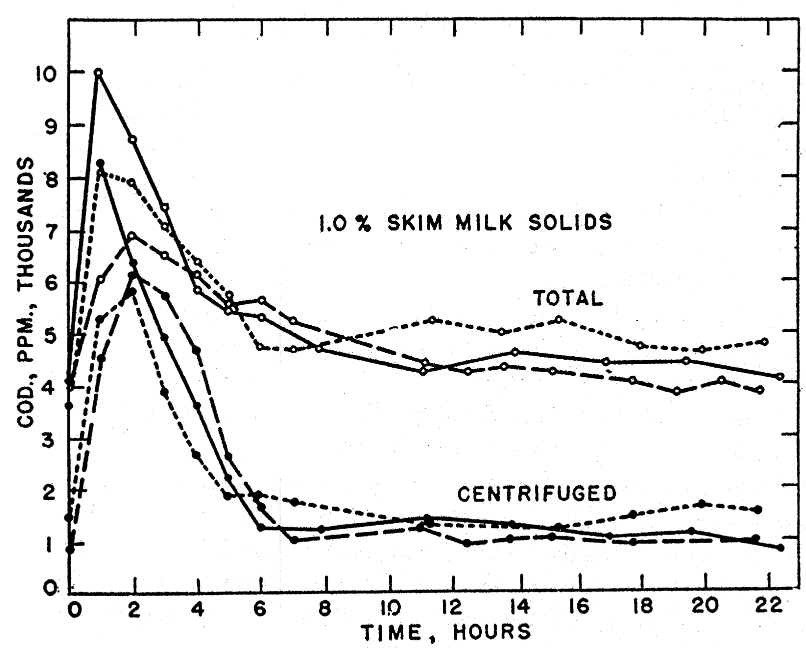

FIGURE 3.

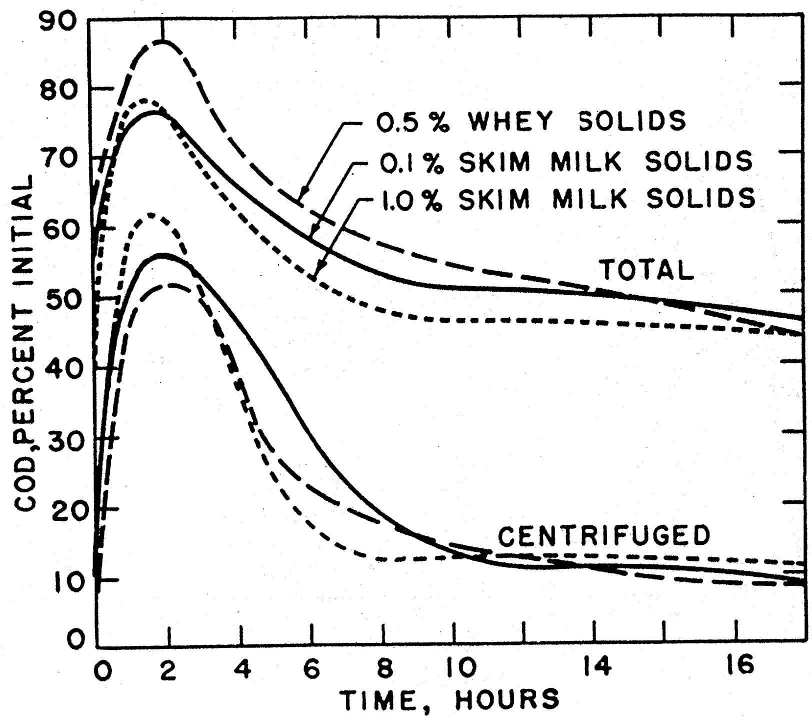

FIGURE 4.

of the oxidation of this solution containing 5000 ppm. C.O.D. or 4300 ppm. B.O.D. was similar to that of the more dilute skim milk solution.

Although a 1.0 per cent solution of skim milk solids would not be an expected effluent from a satisfactorily operated dairy plant, the performance of the system was tested on such a solution. The data (Figure 3) followed the same curve, and oxidation was substantially complete in six hours.

The relationship between these three sets of experiments is shown more clearly by Figure 4, in which the average of each three sets of experiments is plotted as a percentage of the initial C.O.D. of the solution added. In each case, the total C.O.D. was reduced 50 per cent and that of the supernatant about 90 per cent.

Because of the need to treat cheese whey in some plants, preliminary experiments have been made in which solutions of higher whey solids content were used. Similar results were obtained with 2.5 per cent whey solids, a concentration about that of the total effluent of a cheese plant. Experiments with 5 per cent whey solids indicated appreciable reduction in C.O.D., but the conversion to cell substance was incomplete.

Further study of the system with solutions of high solids content is planned.

The results in Figures 1-3 are on a C.O.D. basis, which approximates the 20-day B.O.D. or complete oxidation. B.O.D. determinations at 5 and 20 days were made upon the tank contents after 16-18 hours' aeration. The data in Table 1 show that the reduction in 5-day B.O.D. is greater than the reduction in C.O.D. This difference was caused by the altered chemical nature of the waste. Bacterial cells are oxidized less rapidly by their own endogenous respiration than are the readily available sugar and protein of milk. The results of the 20-day B.O.D. determinations agree with this idea. However, no provision was made to prevent nitrification, and the 20-day B.O.D. tests may have been affected by nitrification.

TABLE 1

ANALYSIS OF WHOLE EFFLUENT FROM FILL-AND-DRAWN OPERATION
(SAMPLES TAKEN 16-18 HOURS AFTER ADDITION OF WASTE)

	Simulated Waste		
	0.1% Skim milk	0.5% Whey	1.0% Skim milk
Initial C.O.D., ppm.	1050	5000	10,500
Final C.O.D., ppm.	448	2220	4,700
C.O.D. % reduction	60	55	55
Initial 5-day B.O.D. ppm	640	4300	6,400
Final 5-day B.O.D., ppm	118	1120	1,560
5-day B.O.D., % reduction	80	75	75
Initial 20-day B.O.D., ppm	1060	5000	10,600
Final 20-day B.O.D., ppm	286	2110	3,100
20-day B.O.D., % reduction	73	58	71

Analyses of the supernatant solution after centrifuging (Table 2) showed rather good agreement in percentage reduction of C.O.D., 5-day B.O.D. and 20-day B.O.D.

A fill-and-draw waste treatment designed on the basis of these experiments would require a relatively simple installation. A tank with a capacity 1.25 times the maximum daily flow would be essential. The temperature should be maintained between 70° and 90° F., preferably between 80° and 90°. An efficient air dispersion system should be provided and vented outside. In small-scale operation occasional odors have been apparent, but with good aeration they would not be expected to be a serious problem. The rate of discharge of effluent is often a major

TABLE 2

ANALYSIS OF CENTRIFUGED EFFLUENT FROM FILL-AND-DRAW OPERATION (SAMPLES TAKEN 16-18 HOURS AFTER ADDITION OF WASTE)

	Simulated Waste		
	0.1% Skim milk	0.5% Whey	1.0% Skim milk
Final C.O.D., ppm	120	312	730
C.O.D., % reduction	89	94	93
Final 5-day B.O.D., ppm	52	190	400
5-day B.O.D., % reduction	92	95	94
Final 20-day B.O.D., ppm	—	340	850
20-day B.O.D., % reduction	—	93	92

factor in the immediate effect upon the receiving stream. The data indicate that, starting at 6 to 8 p.m., the tank could be drained over a period of 12 to 14 hours and have an active fresh "24-hour-old" culture available for the following day's operation. Presumably this draining operation could be controlled by automatic timing devices.

If a milk plant were in a town or city with an overloaded municipal disposal system, a partial treatment might be advantageous in cutting down the industrial waste load. The concurrent alteration in the chemical constituents of the waste would be valuable, for the readily available milk waste would be converted to cells chemically similar to sewage. A further factor worthy of consideration is that the industrial waste so treated would be discharged during the night at a time of low sewage flow.

Finally the results obtained with the centrifuged effluent indicate a high degree of treatment is possible if the sludge is removed from the effluent. The best method of removing this sludge would have to be determined.

SUMMARY

A reduction in C.O.D. of 50-60 per cent and in B.O.D. of about 75 per cent has been obtained by aeration of milk wastes in a relatively simple daily fill-and-draw system. The possibility of applying this system in plants in which such a reduction in pollution would be sufficient are pointed out.

REFERENCES

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